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(54) **METHOD AND SYSTEM FOR PERFORMING OPERATIONS ON DATA USING XML STREAMS**

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This patent is subject to a terminal disclaimer.

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(51) **Int. Cl.**
G06F 9/44 (2006.01)

(52) **U.S. Cl.**
USPC **717/106; 717/107; 717/109**

(58) **Field of Classification Search**
USPC 717/106, 107, 109
See application file for complete search history.

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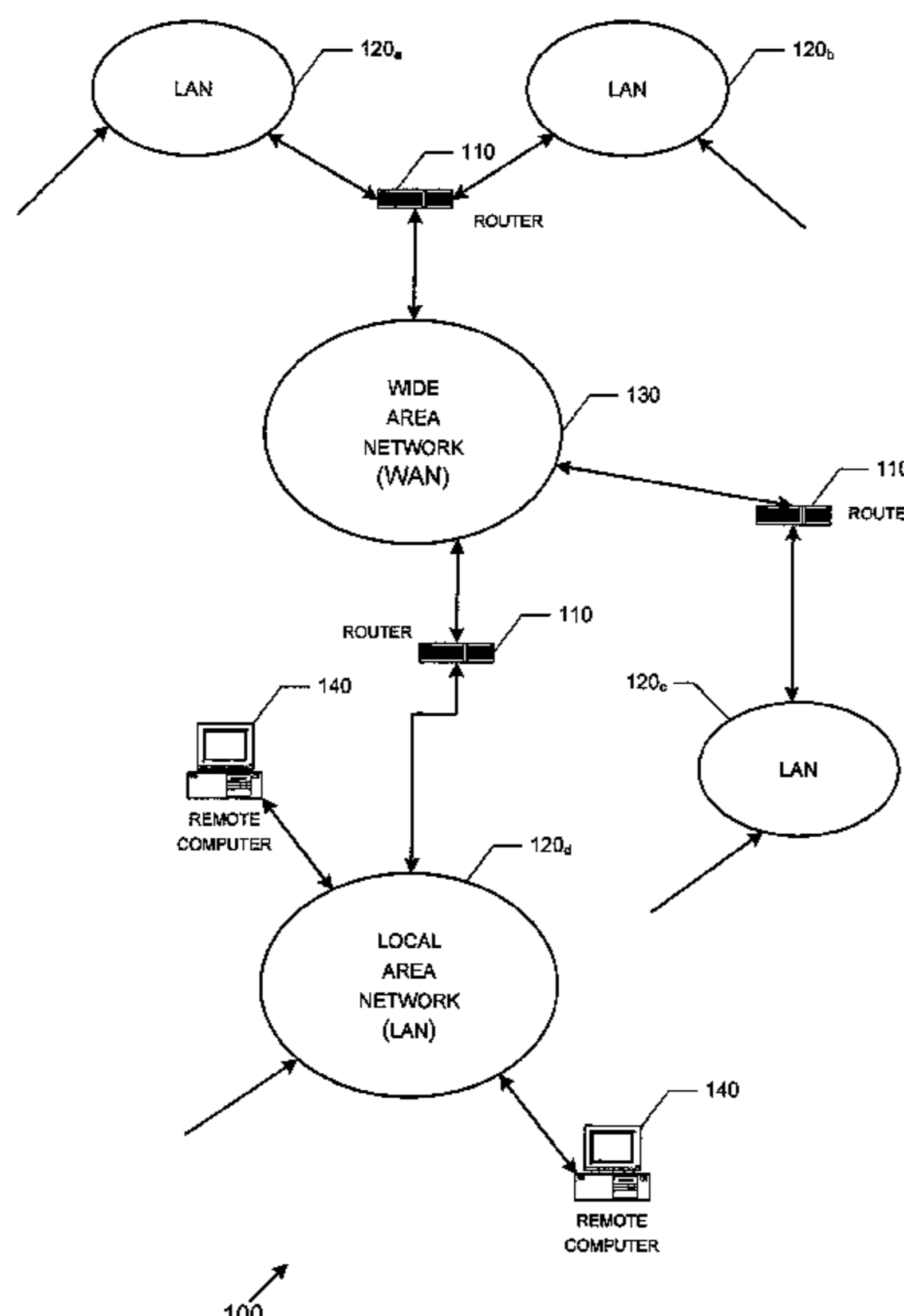
Primary Examiner — Qamrun Nahar

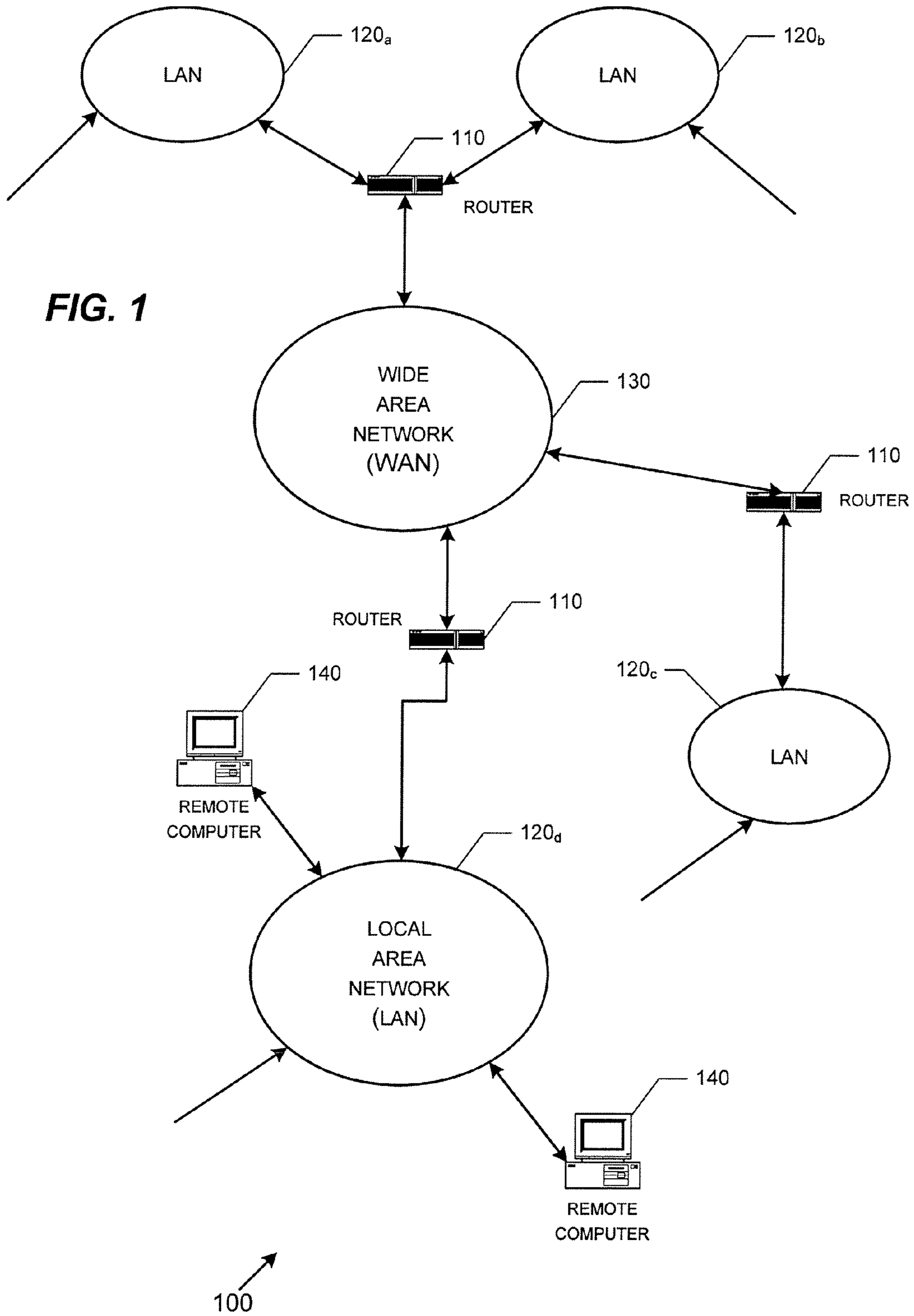
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(57) **ABSTRACT**

The present invention provides a method and system for performing operations on data using XML streams. An XML schema defines a limited set of operations that may be performed on data. These operations include addition, subtraction, multiplication and division. The operations are placed in an XML stream that conforms to the XML schema. The XML stream may perform one or more of the defined operations on the data. The limited set of operations allows data to be validated and processed without excessive overhead.

18 Claims, 5 Drawing Sheets





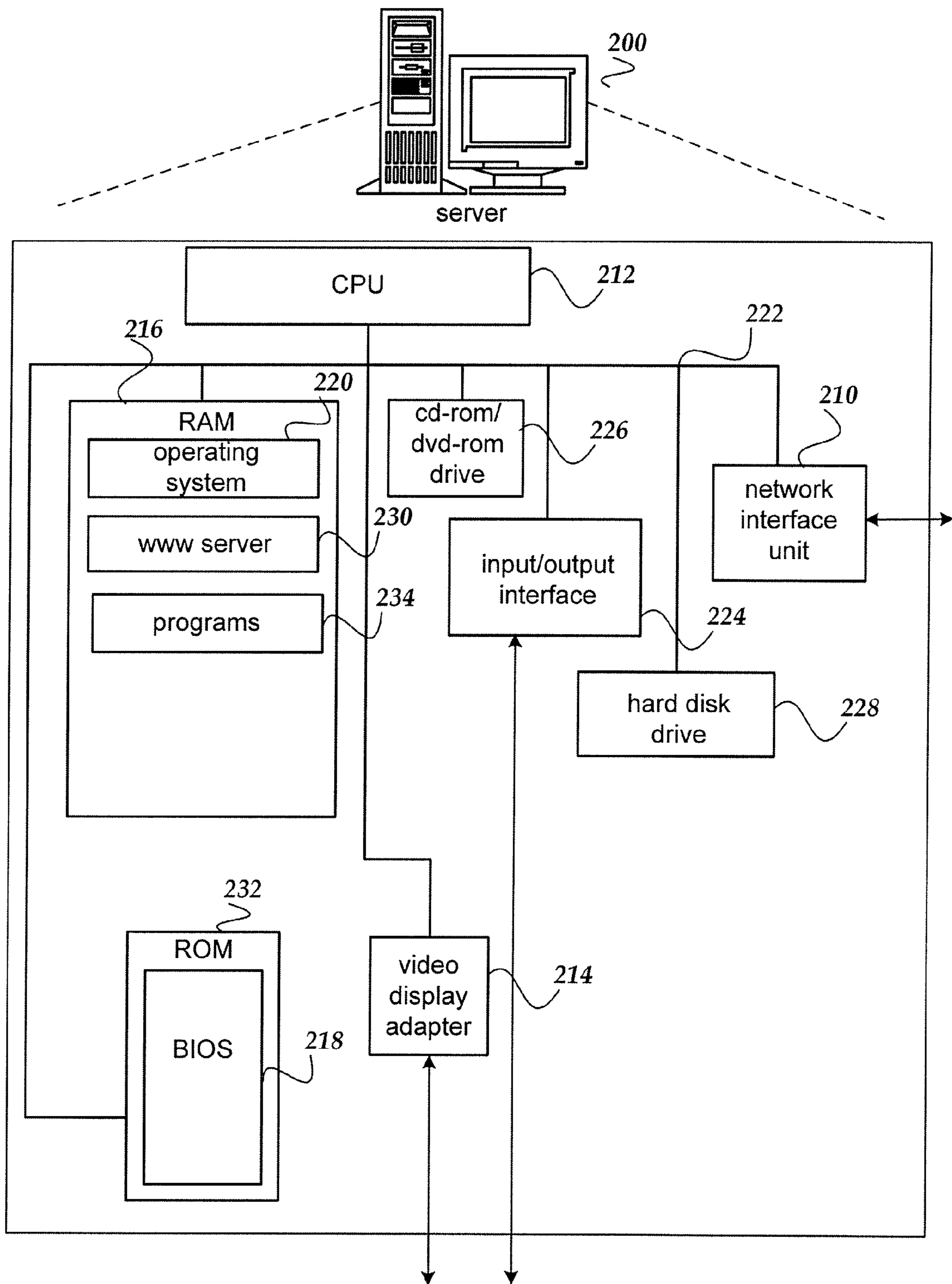


FIG. 2

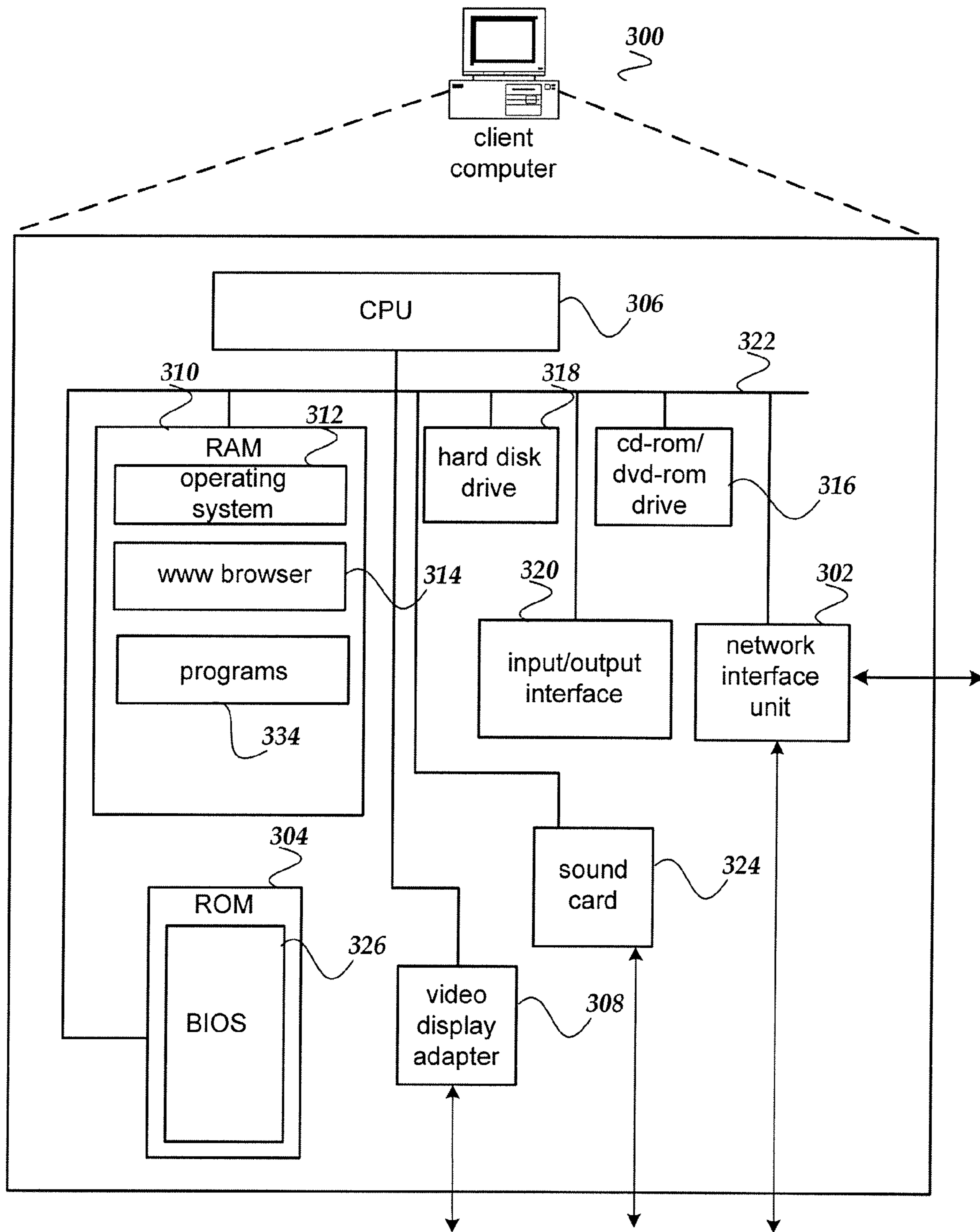


FIG. 3

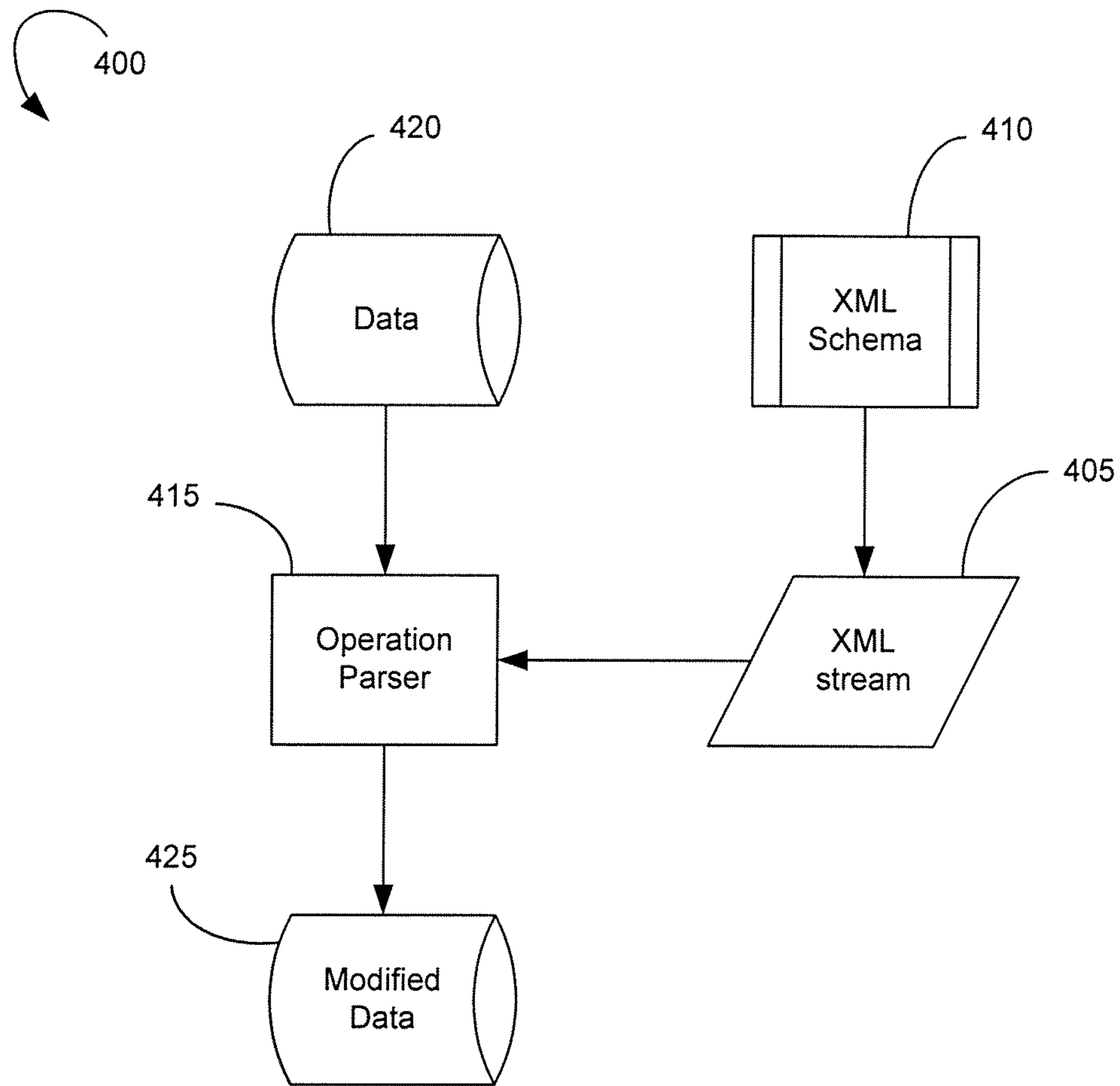


FIG. 4

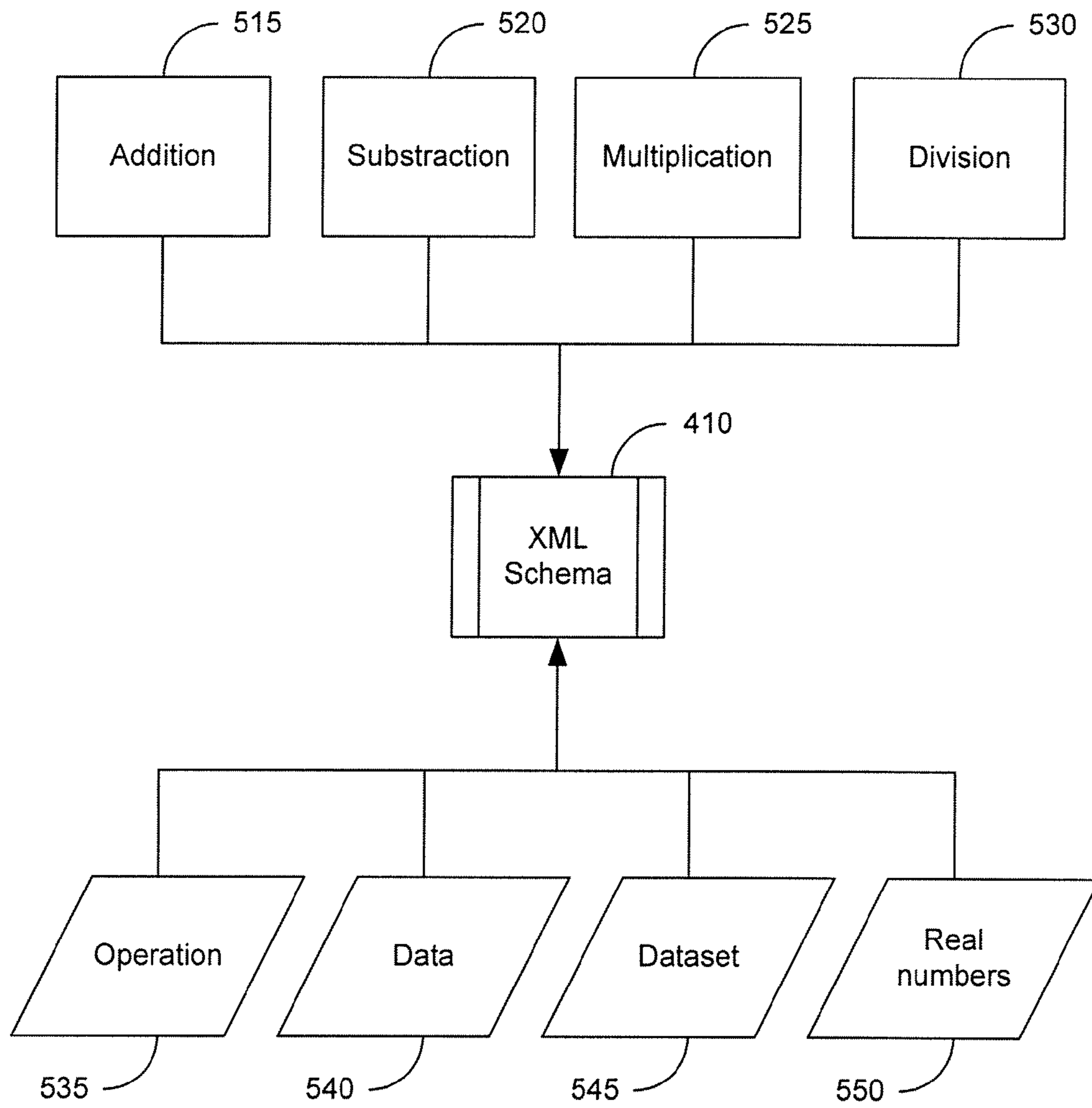


FIG. 5

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METHOD AND SYSTEM FOR PERFORMING OPERATIONS ON DATA USING XML STREAMS

RELATED APPLICATION

This application represents a continuation of patent application "METHOD AND SYSTEM FOR PERFORMING OPERATIONS ON DATA USING XML STREAMS," filed on Dec. 12, 2002, and issued application Ser. No. 10/318,649 now U.S. Pat. No. 7,296,263. The present application claims the priority and benefit of this application under 35 U.S.C. §120.

FIELD OF THE INVENTION

This invention relates generally to computer software, and more particularly to a schema for data processing tools.

BACKGROUND OF THE INVENTION

Extensible Markup Language (XML) has gained wide popularity in recent years, especially in the field of Web development. XML is a universal language that provides a way to identify, exchange, and process various kinds of data. For example, XML is used to create documents that can be utilized by a wide variety of computer application programs. On the Internet, for example, information and data may be distributed among incompatible information repositories using XML. XML provides a mechanism for exchanging data with these entities in a mutually understood fashion.

When passing data between programs, instructions in an XML document may be implemented as an XML stream. An XML stream may contain XML instructions to act on the data. Implementing XML instructions as an XML stream allows the instructions to be transmitted between two locations using a network, such as a Local Area Network (LAN) or the Internet.

An XML schema may be used to define an XML stream. An XML schema comprises of a set of rules written in XML that define the structure of an XML stream. For example, an XML schema may define data types, which may be associated with XML element types and attributes. An XML schema may also describe the structure and constrain the contents of XML streams.

Conventional XML schemas, however, add overhead to an XML stream that transmits data between locations. This overhead causes the XML stream to be transmitted and interpreted slower than what may be desired.

SUMMARY OF THE INVENTION

The present invention is directed towards providing a method and system for performing operations on data using XML streams. An XML schema defines a limited set of operations that may be performed on the data.

According to one aspect of the invention, the operations are restricted by the XML schema and include defined operations for addition, subtraction, multiplication and division. The operations are placed in an XML stream that conforms to the XML schema.

According to another aspect of the invention, the operations defined by the schema are performed on the data by an operation parser. Both the data and the XML stream are passed to an operation parser for performing the desired operations. The parser then performs the operations on the data utilizing the XML stream.

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According to another aspect of the invention, the operations are performed on two operands related to the data. The operands may be of the types that are defined by the XML schema. The element types include operations, data, dataset, and real numbers.

According to yet another aspect of the invention, the XML schema provided reduces overhead in performing operations on the data. The overhead is reduced in part because the XML schema restricts the number of operations that may be included in the XML stream so that the operation parser may rapidly interpret and implement the stream.

These and various other features, as well as advantages that characterize the present invention, will be apparent from a reading of the following detailed description and a review of the associated drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1-3 show components of an exemplary environment in which the invention may be practiced;

FIG. 4 shows a schematic diagram of an operational process where operations are performed on a data by an XML stream; and

FIG. 5 illustrates a schematic diagram of exemplary contents of the XML schema shown in FIG. 4; in accordance with aspects of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In the following detailed description of exemplary embodiments of the invention, reference is made to the accompanied drawings, which form a part hereof, and which are shown by way of illustration, specific exemplary embodiments of which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized, and other changes may be made, without departing from the spirit or scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is defined only by the appended claims.

This invention is directed toward a method and system for performing operations on data using an XML stream that includes a limited number of operations defined by an XML schema.

Illustrative Operating Environment

FIGS. 1-3 show components of an exemplary environment in which the invention may be practiced. Not all the components may be required to practice the invention, and variations in the arrangement and type of the components may be made without departing from the spirit or scope of the invention.

FIG. 1 shows a plurality of local area networks ("LANs") **120_{a-d}** and wide area network ("WAN") **130** interconnected by routers **110**. Routers **110** are intermediary devices on a communications network that expedite message delivery. On a single network linking many computers through a mesh of possible connections, a router receives transmitted messages and forwards them to their correct destinations over available routes. On an interconnected set of LANs (including those based on differing architectures and protocols), a router acts as a link between LANs, enabling messages to be sent from one to another. Communication links within LANs typically include twisted pair, fiber optics, or coaxial cable, while communication links between networks may utilize analog telephone lines, full or fractional dedicated digital lines including T1, T2, T3, and T4, Integrated Services Digital Networks

(ISDNs), Digital Subscriber Lines (DSLs), wireless links, or other communications links known to those skilled in the art. Furthermore, computers, such as remote computer **140**, and other related electronic devices can be remotely connected to either LANs **120_{a-d}** or WAN **130** via a modem and temporary telephone link. The number of WANs, LANs, and routers in FIG. **1** may be increased or decreased arbitrarily without departing from the spirit or scope of this invention.

As such, it will be appreciated that the Internet itself may be formed from a vast number of such interconnected networks, computers, and routers. Generally, the term "Internet" refers to the worldwide collection of networks, gateways, routers, and computers that use the Transmission Control Protocol/Internet Protocol ("TCP/IP") suite of protocols to communicate with one another. At the heart of the Internet is a backbone of high-speed data communication lines between major nodes or host computers, including thousands of commercial, government, educational and other computer systems, that route data and messages. An embodiment of the invention may be practiced over the Internet.

The media used to transmit information in communication links as described above illustrates one type of computer-readable media, namely communication media. Generally, computer-readable media includes any media that can be accessed by a computing device. Computer-readable media may include computer storage media, communication media, or any combination thereof.

Communication media typically embodies computer-readable instructions, data structures, program modules, or other data in a modulated data signal such as a carrier wave or other transport mechanism and includes any information delivery media. The term "modulated data signal" means a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, communication media includes wired media such as twisted pair, coaxial cable, fiber optics, wave guides, and other wired media and wireless media such as acoustic, RF, infrared, and other wireless media.

The Internet has recently seen explosive growth by virtue of its ability to link computers located throughout the world. As the Internet has grown, so has the WWW. Generally, the WWW is the total set of interlinked hypertext documents residing on HTTP (hypertext transport protocol) servers around the world. Documents on the WWW, called pages or Web pages, are typically written in HTML (Hypertext Markup Language), XML, or some other markup language, identified by URLs (Uniform Resource Locators) that specify the particular machine and pathname by which a file can be accessed, and transmitted from server to end user using HTTP.

A server providing a WWW site, as the server described in more detail in conjunction with FIG. **2**, is a computer connected to the Internet having storage facilities for storing hypertext documents for a WWW site and running administrative software for handling requests for the stored hypertext documents. A hypertext document normally includes a number of hyperlinks, i.e., highlighted portions of text which link the document to another hypertext document possibly stored at a WWW site elsewhere on the Internet. Each hyperlink is associated with a URL that provides the location of the linked document on a server connected to the Internet and describes the document. Thus, whenever a hypertext document is retrieved from any WWW server, the document is considered to be retrieved from the WWW. As is known to those skilled in the art, a WWW server may also include facilities for storing and transmitting application programs, such as application programs written in the JAVA programming language

from Sun Microsystems, for execution on a remote computer. Likewise, a WWW server may also include facilities for executing scripts and other application programs on the WWW server itself.

A user may retrieve hypertext documents from the WWW via a WWW browser application program located on a wired or wireless device. A WWW browser, such as Netscape's NAVIGATOR® or Microsoft's INTERNET EXPLORER®, is a software application program for providing a graphical user interface to the WWW. Upon request from the user via the WWW browser, the WWW browser accesses and retrieves the desired hypertext document from the appropriate WWW server using the URL for the document and HTTP. HTTP is a higher-level protocol than TCP/IP and is designed specifically for the requirements of the WWW. HTTP is used to carry requests from a browser to a Web server and to transport pages from Web servers back to the requesting browser or client. The WWW browser may also retrieve application programs from the WWW server, such as JAVA applets, for execution on a client computer.

FIG. **2** shows an exemplary server that may operate to provide a WWW site, among other things. When providing a WWW site, server **200** transmits WWW pages to the WWW browser application program executing on requesting devices to carry out this process. For instance, server **200** may transmit pages and forms for receiving information about a user, such as address, telephone number, billing information, credit card number, etc. Moreover, server **200** may transmit WWW pages to a requesting device that allow a consumer to participate in a WWW site. The transactions may take place over the Internet, WAN/LAN **100**, or some other communications network.

Server **200** may include many more components than those shown in FIG. **2**. However, the components shown are sufficient to disclose an illustrative environment for practicing the present invention. As shown in FIG. **2**, server **200** is connected to WAN/LAN **100**, or other communications network, via network interface unit **210**. Network interface unit **210** includes the necessary circuitry for connecting server **200** to WAN/LAN **100**, and is constructed for use with various communication protocols including the TCP/IP protocol. Typically, network interface unit **210** is a card contained within server **200**.

Server **200** also includes processing unit **212**, video display adapter **214**, and a mass memory, all connected via bus **222**. The mass memory generally includes random access memory ("RAM") **216**, read-only memory ("ROM") **232**, and one or more permanent mass storage devices, such as hard disk drive **228**, a tape drive (not shown), optical drive **226**, such as a CD-ROM/DVD-ROM drive, and/or a floppy disk drive (not shown). The mass memory stores operating system **220** for controlling the operation of server **200**. A general purpose server operating system, such as UNIX, LINUX™, or Microsoft WINDOWS NT® and the like may be used. Basic input/output system ("BIOS") **218** is also provided for controlling the low-level operation of server **200**.

The mass memory as described above illustrates another type of computer-readable media, namely computer storage media. Computer storage media may include volatile and nonvolatile, removable and non-removable media implemented in any method or technology for storage of information, such as computer readable instructions, data structures, program modules or other data. Examples of computer storage media include RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices,

or any other medium which can be used to store the desired information and which can be accessed by a computing device.

The mass memory may also store program code and data for providing a WWW site. More specifically, the mass memory may store applications including WWW server application program **230**, and programs **234**. WWW server application program **230** includes computer executable instructions which, when executed by server **200**, generate WWW browser displays, including performing the logic described above. XML may be interpreted by server **200**. Server **200** may include a JAVA virtual machine, an SMTP handler application for transmitting and receiving email, an HTTP handler application for receiving and handing HTTP requests, JAVA applets for transmission to a WWW browser executing on a client computer, and an HTTPS handler application for handling secure connections. The HTTPS handler application may be used for communication with an external security application to send and receive sensitive information, such as credit card information, in a secure fashion.

Server **200** may also comprise input/output interface **224** for communicating with external devices, such as a mouse, keyboard, scanner, or other input devices not shown in FIG. 2. Likewise, server **200** may further comprise additional mass storage facilities such as optical drive **226** and hard disk drive **228**. Hard disk drive **228** is utilized by server **200** to store, among other things, application programs, databases, and program data used by WWW server application program **230**. For example, customer databases, product databases, image databases, and relational databases may be stored.

FIG. 3 depicts several components of client computer **300**. Client computer **300** may include many more components than those shown in FIG. 3. However, it is not necessary that those generally-conventional components be shown in order to disclose an illustrative embodiment for practicing the present invention. As shown in FIG. 3, client computer **300** includes network interface unit **302** for connecting to a LAN or WAN, or for connecting remotely to a LAN or WAN. Network interface unit **302** includes the necessary circuitry for such a connection, and is also constructed for use with various communication protocols including the TCP/IP protocol, the particular network configuration of the LAN or WAN it is connecting to, and a particular type of coupling medium. Network interface unit **302** may also be capable of connecting to the Internet through a point-to-point protocol ("PPP") connection or a serial line Internet protocol ("SLIP") connection as known to those skilled in the art.

Client computer **300** also includes BIOS **326**, processing unit **306**, video display adapter **308**, sound card **324**, and memory. The memory generally includes RAM **310**, ROM **304** and a permanent mass storage device, such as a disk drive. The memory stores operating system **312** and programs **334** for controlling the operation of client computer **300**. The memory also includes WWW browser **314**, such as Netscape's NAVIGATOR[®] or Microsoft's INTERNET EXPLORER[®] browsers, for accessing the WWW. It will be appreciated that these components may be stored on a computer-readable medium and loaded into memory of client computer **300** using a drive mechanism associated with the computer-readable medium, such as a floppy disk drive (not shown), optical drive **316**, such as a CD-ROM/DVD-ROM drive, and/or hard disk drive **318**. Input/output interface **320** may also be provided for receiving input from a mouse, keyboard, or other input device. The memory, network interface unit **302**, video display adapter **308**, sound card **324**, and input/output interface **320** are all connected to processing unit

306 via bus **322**. Other peripherals may also be connected to processing unit **306** in a similar manner.

As will be recognized from the discussion below, aspects of the invention may be embodied on routers **110**, on server **200**, on client computer **300**, on other network devices (not shown), or on some combination of the above. For example, programming steps may be contained in programs **334** and/or programs **234**.

Illustrative Data Operations

FIG. 4 shows a schematic overview diagram of operational process **100** where operations are performed on data by an XML stream. An XML stream is a flow of data containing instructions in XML. XML stream **405** may contain instructions for performing one or more operations from a set of pre-defined operations. The data types, structure, and contents of XML stream **405** are specified by XML schema **410**. Briefly stated, XML schema **410** includes rules written in XML that define operations that may be included in XML stream **405**. XML schema **410** includes a limited number of defined operations that may be performed, including addition, subtraction, multiplication, and division. XML schema **410** will be explained in more detail in conjunction with reference to FIG. 5.

One or more operations defined by XML schema **410** may be placed in XML stream **405**. Operation parser **415** receives data from data **420** and at least one operation from the defined operations within XML stream **405**. Operation parser **415** performs the operations contained within XML stream **405** on data **420**. Data **420** may be in many different forms. For example, data **420** may be a single data point, or a set of data points. Additionally, the data may be of various types, including but not limited to: real numbers, integers, pointers, strings, and operations. Operation parser **415** operates on data **420** utilizing XML stream **405** and outputs modified data **425**. Modified data **425** is modified in accordance with the instructions contained within XML stream **405**. Modified data **425** may then be used by another process (not shown).

XML stream **405** and data **420** may be passed to operation parser **415** at any time. According to one embodiment, XML stream **405** and data **420** is passed to operation parser **415** at predetermined times. For example, operation parser acts on the data every 50 milliseconds. According to another embodiment, XML stream **405** is passed to operation parser **115** when data **420** is received by operation parser **415**.

FIG. 5 illustrates a schematic diagram of an exemplary XML schema **410** as shown in FIG. 4. XML schema **410** is used to describe data types, structure, and contents of XML stream **405**. As illustrated, XML schema **410** includes definitions for four types of operations, including: addition **515**, subtraction **520**, multiplication **525**, and division **530**. XML schema **410** also includes definitions for four types of elements: data **540**, dataset **545**, operation **535**, and real number **550**. Data **540** is a single unit of data and datasets **545** is a set of data that contains multiple units of data, such as a data array. Data **540** and dataset **545** will be discussed in more detail in conjunction with TABLES 2, 3, and 4 below. Operation **535** performs one of the four types of operations. These operations may be performed on the four element types. Operation **535** will be discussed in more detail in conjunction with TABLES 5 to 10.

TABLE 1 shows a block of code in an exemplary XML schema for defining a primary set of arithmetic operations in an XML stream, such as XML stream **405** of FIG. 1. The code block in TABLE 1 defines operations that may be performed on data using the XML stream. These operations include addition, subtraction, multiplication, and division. The operations that may be included in the XML stream are restricted to

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the four operations. This restriction, which limits the content of the XML stream, allows the stream to be efficiently validated and rapidly performed.

TABLE 1

Primary set of arithmetic operations.
<pre><xsd:simpleType name="kindofOperationDef"> <xsd:restriction base="xsd:string"> <xsd:pattern value="addition"/> <xsd:pattern value="subtraction"/> <xsd:pattern value="multiplication"/> <xsd:pattern value="division"/> </xsd:restriction> </xsd:simpleType></pre>

TABLE 2 shows a block of code in an exemplary XML schema for defining the data element type. The term "data element type" includes a single unit of data. The code block in TABLE 2 defines the data element type as a number string.

TABLE 2

Definition for data element type.
<pre><xsd:simpleType name="dataIDDef"> <xsd:restriction base="xsd:string"> <xsd:pattern value="p{Nd}+"/> </xsd:restriction> </xsd:simpleType></pre>

TABLE 3 illustrates a block of code in an exemplary XML schema for defining the dataset element type. The term "dataset element type" includes a set of data, such as a data array, that contains multiple units of data. The code block in TABLE 3 specifies the type of pre-operations that may be applied to the units of data within the dataset prior to operating on the dataset as a whole. These pre-operations include addition, subtraction, multiplication, and division. Furthermore, the code block in TABLE 3 specifies the types of data that may be included within the dataset element type. The units of data within a dataset element type are of the data element type, which includes a string with numbers.

TABLE 3

Definition for dataset element type.
<pre><xsd:complexType name="dataIDSetDef"> <xsd:sequence> <xsd:element name="setOperation" type="kindofOperationDef"/> <xsd:element name="setMember" type="dataIDDef" maxOccurs="unbounded"/> </xsd:sequence> </xsd:complexType></pre>

TABLE 4 illustrates a block of code in an exemplary XML schema for specifying an alternative to the dataset element type that was defined by the code block shown in TABLE 3. The code block in TABLE 4 specifies that the pre-operations of the dataset element type include the operations defined by the code block shown in TABLE 1. However, unlike the code block in TABLE 3, the code block of TABLE 4 restricts the type of pre-operation to addition.

TABLE 4

Definition for an alternative dataset element type.
<pre><xsd:complexType name="summedDataIDSetDef"> <xsd:complexContent> <xsd:restriction base="dataIDSetDef"></pre>

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TABLE 4-continued

Definition for an alternative dataset element type.
<pre><xsd:sequence> <xsd:element name="setMember" type="dataIDDef"/> </xsd:sequence> </xsd:restriction> </xsd:complexContent> </xsd:complexType></pre>

TABLE 5 summarizes the possible types of operations that may be carried out by an exemplary operation (O1) on different operand combinations. An operand contains data on which an operation may operate. An operation may be defined to operate on one or more operands. According to one embodiment of the invention, the operation is performed on two operands. As shown in TABLE 5, the types of operations that may be performed by operation O1 include addition, subtraction, multiplication, and division. TABLE 5 also lists the various types of operand combinations that are accepted by operation O1. As defined, operation O1 may operate on two operands, which may be of four different element types: data, dataset, operations, and real numbers. For example, the first operand may be data a, dataset A, operation O2, or real number R1, the second operand may be data b, dataset B, operation O2, or real number R2.

TABLE 5

Summary of operand combinations.				
Operand Combinations	Addition	Subtraction	Multiplication	Division
O1(a,b)	X	X	X	X
O1(A,B)	X	X	X	X
O1(O2,O3)	X	X	X	X
O1(R1,R2)	X	X	X	X
O1(a,B)	X	X	X	X
O1(a,O3)	X	X	X	X
O1(a,R2)	X	X	X	X
O1(A,b)	X	X	X	X
O1(A,O3)	X	X	X	X
O1(A,R2)	X	X	X	X
O1(O2,b)	X	X	X	X
O1(O2,B)	X	X	X	X
O1(O2,R2)	X	X	X	X
O1(R1,b)	X	X	X	X
O1(R1,B)	X	X	X	X
O1(R1,O2)	X	X	X	X

TABLES 6 to 10 show exemplary blocks of code in an XML schema for specifying an operation and different types of operands that may be accepted by the operation.

The code block in TABLE 6 specifies the operation to include addition, subtraction, multiplication, and division. The code block also includes an example sequence for defining a combination of two operands. A sequence specifies two operands that may be operated on by the operation. The sequence specifies that both operands be of data element type. As discussed above, data element type may be a string that has characters that are restricted to numbers. As indicated in TABLE 6, additional sequences with operands of other element types may be included in the code block. Four other exemplary sequences in the context of the code block in Table 6 are shown in TABLES 7, 8, 9 and 10 below.

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TABLE 6

Define operations with two data element type operands.

```

<xsd:element name="kindofOperation" type="kindofOperationDef"/>
<xsd:element name="OperationElement" type="dataIDDef"/>
<xsd:element name="OperationSet" type="summedDataIDSetDef"/>
<xsd:element name="SubOperation" type="operationDef"/>
<xsd:element name="Real" type="xsd:double"/>
<xsd:complexType name="operationDef">
  <xsd:sequence>
    <xsd:element ref="kindofOperation"/> <xsd:choice>
      (Choices of operand combinations are shown in Table 5 above. Specific
      examples are elaborated below.)
    </xsd:choice>
  </xsd:sequence>
</xsd:complexType>

```

TABLE 7 shows an exemplary sequence that specifies a combination of two operands where both operands are data elements. The sequence specifies the dataset elements as the type that was defined by the code block in TABLE 2.

TABLE 7

Define operations with two data element type operands.

```

<xsd:sequence>
  <xsd:element ref="OperationElement"/>
  <xsd:element ref="OperationElement"/>
</xsd:sequence>

```

TABLE 8 shows an exemplary sequence that specifies a combination of two operands where both operands are summed dataset elements. The sequence specifies the dataset elements as the type that was defined by the code block in TABLE 4, where the pre-operation of the dataset element is restricted to addition.

TABLE 8

Define operations with two dataset element type operands.

```

<xsd:sequence>
  <xsd:element ref="OperationSet"/>
  <xsd:element ref="OperationSet"/>
</xsd:sequence>

```

TABLE 9 shows an exemplary sequence that specifies a combination of two operands where both operands are operation elements. The sequence specifies the operation element as the type that is defined by the code block in TABLE 6.

TABLE 9

Define operations with two operation element type operands.

```

<xsd:sequence>
  <xsd:element ref="SubOperation"/>
  <xsd:element ref="SubOperation"/>
</xsd:sequence>

```

TABLES 10 and 11 show two exemplary sequences that specify two operand combinations. The sequence in TABLE 10 specifies a combination of two operands where both operands are real numbers. TABLE 11 shows a sequence that specifies a combination where the first operand is a data element and the second operand is a real number. Other combinations of operands, as indicated in TABLE 5, may be specified by sequences similar to those shown in TABLES 7, 8, 9, 10, and 11.

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TABLE 10

Define operations with two real number element type operands.

```

<xsd:sequence>
  <xsd:element ref="Real"/>
  <xsd:element ref="Real"/>
</xsd:sequence>

```

TABLE 11

Define operations one data element type operand and one real number element type operand.

```

<xsd:sequence>
  <xsd:element ref="OperationElement"/>
  <xsd:element ref="Real"/>
</xsd:sequence>

```

TABLE 12 shows a block of code that defines the top-level container element of the XML schema. The top-level container element includes sub-elements that are groups of operations, where the operations are defined by the code block shown in TABLE 6. Groups of operations are summations of all of their sub elements. The fact that they are summations is implicit in the group definition, and is referred to in the name of the element.

TABLE 12

Validation.

```

<xsd:complexType name="summedOperationGroupDef">
  <xsd:sequence>
    <xsd:element name="operationGroupElement" type="operationDef"
      maxOccurs="unbounded"/>
  </xsd:sequence>
</xsd:complexType>

```

TABLE 13 illustrates an exemplary XML stream for performing an operation "DataID 1011+DataID 1211." The stream specifies that addition is the type of the operation to be performed. In order to be valid the OperationGroupElement tag of this stream is included in a SummedOperationGroupDef tag. In this XML stream, both operands are data elements, as defined by the XML schema shown in TABLES 2 and 6. Thus, in this XML stream, the first operand is data unit with DataID 1011; the second operand is data unit with DataID 1211; and adding the two operands performs the operation.

TABLE 13

operation: DataID 1011 + DataID 1211.

```

<operationGroupElement>
  <kindofOperation>addition</kindofOperation>
  <OperationElement>1011</OperationElement>
  <OperationElement>1211</OperationElement>
</operationGroupElement>

```

TABLE 14 shows an exemplary XML stream for performing an operation "((DataID 1221)/90.3)+((DataID 20021)*(DataID 2001))." This operation includes three operative steps. The first step of the operation involves dividing data unit DataID 1221 by the real number 90.3. The second step of the operation multiplies data unit DataID 20021 by data unit DataID 2001. The first step and second step can be performed in reverse order and that operation precedence happens implicitly because of the way that the schema tags encapsulate the individual operations. The third step of the operation

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adds the result from the first step of the operation and the result from the second step of the operation.

TABLE 14

operation: ((Data ID 1221) / 90.3) + ((DataID 20021)*(DataID 2001)).	
<operationDef>	
<kindofOperation>addition</kindofOperation>	
<SubOperation>	
<kindofOperation>division</kindofOperation>	
<OperationElement>1221</firstOperationElement>	
<Real>90.3</secondReal>	
</SubOperation>	
<SubOperation>	
<kindofOperation>multiplication</kindofOperation>	
<OperationElement>20021</firstOperationElement>	
<OperationElement>2001</secondOperationElement>	
</SubOperation>	
</operationDef>	

TABLE 15 shows an exemplary XML stream for performing an operation “DataID 1221 – (DataID 1332 + DataID 1552).” This operation includes two operative steps. The first step of the operation involves adding data unit DataID 1332 and data unit DataID 1552. The second step of the operation adds data units DataID 1221 with the result of the first step of the operation.

TABLE 15

operation: DataID 1221 – (DataID 1332 + DataID 1552)	
<operationDef>	
<kindofOperation>subtraction</kindofOperation>	
<OperationElement>1221</OperationElement>	
<SubOperation>	
<kindofOperation>addition</kindofOperation>	
<OperationElement>1332</OperationElement>	
<OperationElement>1552</OperationElement>	
</SubOperation>	
</operationDef>	

To further illustrate the present invention, TABLE 16 shows an exemplary XML schema that defines a set of primitives and a set of operations that may be performed on those primitives by XML streams that conform to the schema.

TABLE 15

Exemplary XML schema for defining XML stream operations.	
<?xml version=“1.0” encoding=“utf-8”?>	
<xsd:schema xmlns:xsd=“http://www.w3.org/2001/XMLSchema”	
xmlns:xsi=“http://www.w3.org/2000/10/XMLSchema-instance”>	
<!-- data identifier (data access is abstracted, this is just the access key) -->	
<xsd:simpleType name=“dataIDDef”>	
<xsd:restriction base=“xsd:string”>	
<xsd:pattern value=“p{N}+”/>	
</xsd:restriction>	
</xsd:simpleType>	
<!-- kind of operation, limited to basic arithmetic ops-->	
<xsd:simpleType name=“kindofOperationDef”>	
<xsd:restriction base=“xsd:string”>	
<xsd:pattern value=“addition”/>	
<xsd:pattern value=“subtraction”/>	
<xsd:pattern value=“multiplication”/>	
<xsd:pattern value=“division”/>	
</xsd:restriction>	
</xsd:simpleType>	
<!-- a dataset is defined as a group of dataIDs that has a defined operation -->	
<!-- applied to the group prior to applying any operations to the group as a whole -->	
<xsd:complexType name=“dataIDSetDef”>	

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TABLE 15-continued

Exemplary XML schema for defining XML stream operations.	
<xsd:sequence>	
<xsd:element name=“setOperation” type=“kindofOperationDef”/>	
<xsd:element name=“setMember” type=“dataIDDef”	
maxOccurs=“unbounded”/>	
</xsd:sequence>	
</xsd:complexType>	
<!-- the simplest type of data collection is one where the →	
<!-- contents of the data collection -->	
<!-- are summed prior to group operation. This type of data collection →	
<!-- has no explicit setOperation element because -->	
<!-- the setOperation is restricted to addition -->	
<xsd:complexType name=“summedDataIDSetDef”>	
<xsd:complexContent>	
<xsd:restriction base=“dataIDSetDef”>	
<xsd:sequence>	
<xsd:element name=“setMember” type=“dataIDDef”/>	
</xsd:sequence>	
</xsd:restriction>	
</xsd:complexContent>	
</xsd:complexType>	
<!-- all combos of element, summedElementSet, subOperations, reals -->	
<!-- extend this for different element sets if necessary -->	
<xsd:element name=“kindofOperation” type=“kindofOperationDef”/>	
<xsd:element name=“Operation Element” type=“dataIDDef”/>	
<xsd:element name=“OperationSet” type=“summedDataIDSetDef”/>	
<xsd:element name=“SubOperation” type=“operationDef”/>	
<xsd:element name=“Real” type=“xsd:double”/>	
<!-- operationDef: combinations of elements in basic operations. Note	
recursive nesting of Operations is allowed. -->	
<xsd:complexType name=“operationDef”>	
<xsd:sequence>	
<xsd:element ref=“kindofOperation”/>	
<xsd:choice>	
<xsd:sequence>	
<xsd:element ref=“OperationElement”/>	
<xsd:element ref=“OperationElement”/>	
</xsd:sequence>	
<xsd:sequence>	
<xsd:element ref=“OperationSet”/>	
<xsd:element ref=“OperationSet”/>	
</xsd:sequence>	
<xsd:sequence>	
<xsd:element ref=“SubOperation”/>	
<xsd:element ref=“SubOperation”/>	
</xsd:sequence>	
<xsd:sequence>	
<xsd:element ref=“Real”/>	
<xsd:element ref=“Real”/>	
</xsd:sequence>	
<xsd:sequence>	
<xsd:element ref=“OperationElement”/>	
<xsd:element ref=“OperationSet”/>	
</xsd:sequence>	
<xsd:sequence>	
<xsd:element ref=“OperationElement”/>	
<xsd:element ref=“SubOperation”/>	
</xsd:sequence>	
<xsd:sequence>	
<xsd:element ref=“OperationSet”/>	
<xsd:element ref=“SubOperation”/>	
</xsd:sequence>	
<xsd:sequence>	
<xsd:element ref=“OperationSet”/>	
<xsd:element ref=“Real”/>	
</xsd:sequence>	
<xsd:sequence>	
<xsd:element ref=“SubOperation”/>	
<xsd:element ref=“OperationElement”/>	
</xsd:sequence>	
<xsd:sequence>	

TABLE 15-continued

Exemplary XML schema for defining XML stream operations.

```

<xsd:element ref="SubOperation"/>
<xsd:element ref="OperationSet"/>
</xsd:sequence>
<xsd:sequence>
  <xsd:element ref="SubOperation"/>
  <xsd:element ref="Real"/>
</xsd:sequence>
<xsd:sequence>
  <xsd:element ref="Real"/>
  <xsd:element ref="OperationElement"/>
</xsd:sequence>
<xsd:sequence>
  <xsd:element ref="Real"/>
  <xsd:element ref="OperationSet"/>
</xsd:sequence>
<xsd:sequence>
  <xsd:element ref="Real"/>
  <xsd:element ref="SubOperation"/>
</xsd:sequence>
</xsd:choice>
</xsd:sequence>
</xsd:complexType>
<xsd:complexType name="operationGroupDef">
  <xsd:sequence>
    <xsd:element name="operationGroupElement" type="
"operationDef" maxOccurs="unbounded"/>
  </xsd:sequence>
</xsd:complexType>
<!-- standalone element definitions -->
<xsd:element name="dataIDElement" type="dataIDDef"/>
<xsd:element name="dataIDSet" type="dataIDSetDef"/>
<xsd:element name="summedDataIDSet" type="
"summedDataIDSetDef"/>
<xsd:element name="operation" type="operationDef"/>
<xsd:element name="operationGroup" type="operationGroupDef"/>
</xsd:schema>

```

The above specification and examples provide a complete description of the invention. Since many embodiments of the invention can be made without departing from the spirit and scope of the invention, the invention resides in the claims hereinafter appended.

What is claimed is:

1. A method comprising:
 - receiving by a server computing device extensible markup language (XML) instructions included in an XML schema defining at least a set of arithmetic operations performable on data and one or more operand types on which each of the operations are to be performed;
 - based on the XML instructions, generating by the server computing device an XML stream specifying one or more of the set of arithmetic operations and identifying at least one operand of one of the one or more operand types associated with each of the one or more of the set of arithmetic operations; and
 - transmitting by the server computing device the XML stream to a parser configured to receive data associated with the at least one operand identified in the XML stream and perform the one or more of the set of arithmetic operations specified in the stream on the received data to produce modified data.
2. The method of claim 1, further comprising causing by the server computing device the parser to process the data according to the instructions to yield modified data.
3. The method of claim 1, wherein the operations performable on the data include one or more of addition, subtraction, multiplication, and division.
4. The method of claim 1, wherein the XML schema further defines element types each corresponding to one of the operand types.

5. The method of claim 4, wherein the element types comprise operations, data, dataset, and real numbers.

6. The method of claim 4, wherein the at least one operand comprises a plurality of operands at least one of which is a dataset element having data units.

7. A non-transitory computer readable medium having stored thereon instructions comprising machine executable code which when executed by a processor, causes the processor to perform steps comprising:

receiving extensible markup language (XML) instructions included in an XML schema defining at least a set of arithmetic operations performable on data and one or more operand types on which each of the operations are to be performed;

based on the XML instructions, generating an XML stream specifying one or more of the set of arithmetic operations and identifying at least one operand of one of the one or more operand types associated with each of the one or more of the set of arithmetic operations; and

transmitting the XML stream to a parser configured to receive data associated with the at least one operand identified in the XML stream and perform the one or more of the set of arithmetic operations specified in the stream on the received data to produce modified data.

8. The medium as set forth in claim 7 further having stored thereon instructions comprising machine executable code which when executed by the processor, causes the processor to perform steps further comprising causing the parser to process the data according to the instructions to yield modified data.

9. The medium as set forth in claim 7, wherein the operations performable on the data include one or more of addition, subtraction, multiplication, and division.

10. The medium as set forth in claim 7 wherein the XML schema further defines element types each corresponding to one of the operand types.

11. The medium as set forth in claim 10 wherein the element types comprise operations, data, dataset, and real numbers.

12. The medium as set forth in claim 10 wherein the at least one operand comprises a plurality of operands at least one of which is a dataset element having data units.

13. A server computing device comprising:

one or more processors;

a memory coupled to the one or more processors, the one or more processors configured to execute programmed instructions stored in the memory comprising:

receiving extensible markup language (XML) instructions included in an XML schema defining at least a set of arithmetic operations performable on data and one or more operand types on which each of the operations are to be performed;

based on the XML instructions, generating an XML stream specifying one or more of the set of arithmetic operations and identifying at least one operand of one of the one or more operand types associated with each of the one or more of the set of arithmetic operations; and

transmitting the XML stream to a parser configured to receive data associated with the at least one operand identified in the XML stream and perform the one or more of the set of arithmetic operations specified in the stream on the received data to produce modified data.

14. The device as set forth in claim 13 wherein the one or more processors is further configured to execute programmed instructions stored in the memory for further comprising fur-

ther comprising causing the parser to process the data according to the instructions to yield modified data.

15. The device as set forth in claim **13** wherein the operations performable on the data include one or more of addition, subtraction, multiplication, and division. 5

16. The device as set forth in claim **13** wherein the XML schema further defines element types each corresponding to one of the operand types.

17. The device as set forth in claim **16** wherein the element types comprise operations, data, dataset, and real numbers. 10

18. The device as set forth in claim **16** wherein the at least one operand comprises a plurality of operands at least one of which is a dataset element having data units.

* * * * *